What Is the Milky Way?

The Milky Way is a popular candy bar. The Milky Way is also a part of space. Write YES in front of all of the statements below that describe the Milky Way in space, and NO in front of all the statements that do not describe the Milky Way in space.

_____ **A** a faint band of light across the sky that can be seen on a very dark night

_____ **B** a spiral-shaped group of many stars

_____ **C** a galaxy

_____ **D** our home in the universe

_____ **E** a section of the universe smaller in size than our solar system

_____ **F** a milky-looking area that stretches across the entire universe

_____ **G** a cloud of space dust and debris from planets and stars

_____ **H** a section of the universe that does not include our solar system

_____ **I** billions of stars bound together by gravity

_____ **J** a spiral galaxy in the Virgo cluster of galaxies, 54 million light-years from Earth

In your own words, what is the Milky Way? How does it appear from Earth? How would it appear if we could see it from far out in space?

_____

_____

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What Is the Milky Way?

Teacher Notes

Purpose

The purpose of this assessment probe is to elicit students' ideas about our home galaxy, the Milky Way. The probe is designed to reveal whether students recognize that our solar system is inside the Milky Way, that on clear moonless nights we can see the disc of the Milky Way as a faint band of light across the sky, and that from far out in space our home galaxy would appear as a brightly lit spiral.

Related Concepts

Galaxies
Objects in the sky
Stars: locations

Explanation

The best answers are A, B, C, D, and I. Following is a comment on each of the possible responses.

A. *YES, the Milky Way is a faint band of light across the sky that can be seen on a very dark night.* This is how the Milky Way appears with no city lights or clouds and no Moon. Ancient people who observed this band of light did not know what they were looking at, but they named it the Milky Way since it looked a little like a faint stream of spilled milk. In 1609 Galileo was the first to use a telescope to see that the faint band of light consists of countless stars.

B. *YES, the Milky Way is a spiral-shaped group of many stars.* By measuring the speed and location of stars and clouds of gas and dust, it has been possible to recognize the overall spiral shape of our galaxy. It is similar to many others that we can see from a significant distance.

C. *YES, the Milky Way is a galaxy.* There are billions of galaxies in the universe. Our Milky Way is one of them.

D. *YES, the Milky Way is our home in the universe.* Our home is in a tiny corner of the Milky Way, about two-thirds of the way from the center in one of the spiral arms.

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E. *NO, the Milky Way is NOT a section of the universe smaller in size than our solar system.* It is much bigger than our solar system.
F. *NO, the Milky Way is NOT a milky-looking area that stretches across the entire universe.* It is much smaller than the entire universe.
G. *NO, the Milky Way is NOT a cloud of space dust and debris from planets and stars.* Although it does contain such debris, it also contains billions of stars.
H. *NO, the Milky Way is NOT a section of the universe that does not include our solar system.* Our solar system is a part of the Milky Way.
I. *YES, the Milky Way does contain billions of stars bound together by gravity.* There are billions of galaxies and each one, including the Milky Way, consists of a gravitationally bound cluster of billions of stars.
J. *NO, the Milky is NOT part of the Virgo cluster of galaxies, 54 million light-years from Earth.* Since we are inside the Milky Way galaxy, it cannot be far away from Earth.

In summary, the Milky Way is a galaxy—a large group of billions of stars. Since the solar system is inside the Milky Way, we cannot see it as a spiral. However, on a very dark and clear night we can see the disc edge-on as a faint band of light that stretches across the sky. If we could view it from far out in space, it would look like a lighted pinwheel with a bar across the middle and a bright center. Excellent time-lapse views of the Milky Way observed from Earth are available at: *www.youtube.com/watch?v=hRs8aseQikA&feature=related*

A video of an imaginary journey from Earth to outside the Milky Way is available at *www.youtube.com/watch?v=sm-ucbDVyRU.*

Administering the Probe

This probe can be used with students in middle school and high school. This justified list probe can also be used as a card sort in which the answer choices are put on cards and students sort them into the cards that describe the Milky Way and ones that do not (Keeley 2008). Be aware that for students to understand some of the answer choices in this probe, some prior instruction or experience in learning about galaxies is required. You may remove some of the answer choices that are unfamiliar to students.

Related Ideas in *Benchmarks for Science Literacy* (AAAS 2009)

6–8 The Universe

- The Sun is many thousands of times closer to the Earth than any other star. Light from the Sun takes a few minutes to reach the Earth, but light from the next nearest star takes a few years to arrive. The trip to that star would take the fastest rocket thousands of years.
- Some distant galaxies are so far away that their light takes several billion years to reach the Earth. People on Earth, therefore, see them as they were that long ago in the past.
- ★ The Sun is a medium-sized star located near the edge of a disc-shaped galaxy of stars, part of which can be seen as a glowing band of light that spans the sky on a very clear night.

★ Indicates a strong match between the ideas elicited by the probe and a national standard's learning goal.

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Related Ideas in *National Science Education Standards* (NRC 1996)

9–12 The Origin and Evolution of the Universe

- Billions of galaxies, each of which is a gravitationally bound cluster of stars, now form most of the visible mass in the universe.

Related Research

- Friedman (2008) found that misconceptions regarding the size, extent, and composition of the Milky Way are rampant among middle school and high school students. Although no students participating in the study expressed the belief that the Milky Way is made of milk, they were at a loss regarding its composition aside from stars. Although some students were familiar with images of the Orion Nebula or the Ring Nebula, no one could identify the relationship of those objects to stars. Most students also considered the Sun, the Earth, and the solar system as unique members of the galaxy. The researcher also reported:

  Another prevailing misconception was that the Milky Way spans the entire Universe, or rather that there is no distinction between the two. Yet even among students who could correctly identify the Milky Way as a distinct entity residing in a greater universe, there was still a prevailing misconception regarding the relative size of the Solar System within the Milky Way. On the 60-foot scale of the model we constructed, students were shocked to learn that the entire Solar System could be contained within the width of a human hair. Most students expected the Solar System and galactic scales to be similar. Still, some could not identify that the Solar System resided within the Milky Way at all. (Friedman 2008, p. 179)

- Sadler et al. (2010) developed and validated a multiple-choice assessment item test bank for astronomy and space science in which the alternative answers for each question were based on research findings about common misconceptions. Results were reported for a sample of 7,599 students and their 88 teachers on the MOSART (Misconceptions-Oriented Standards-Based Assessment Resources for Teachers) website: *www.cfa.harvard.edu/smgphp/mosart/aboutmosart_2.html*. Items are listed for grades K–4, 5–8, and 9–12. Since each question has five answer choices, the odds of selecting the correct answer by chance are 20%. One item was as follows:

  Which answer shows the most accurate pattern of the three objects in order from closest object to the Earth to farthest from the Earth?

  A. Center of Milky Way → Andromeda galaxy → North Star
  B. Center of Milky Way → North Star→ Andromeda galaxy
  C. Andromeda galaxy → North Star → center of Milky Way
  D. North Star → Andromeda galaxy → center of Milky Way
  E. North Star → center of Milky Way → Andromeda galaxy

  The correct answer, E, was given by 36%. According to the researchers: "Although the correct choice was the most popular, 27% chose C, which places the North Star farther away than the Andromeda galaxy. Clearly those students (as well as the 35% combined choosing A, B or D) have little understanding of the relative distance of objects in the sky."

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Suggestions for Instruction and Assessment

Although elementary students may have heard of the Milky Way, the concept of galaxies is not addressed until the middle school and high school levels. Helping students understand that our planet and solar system is inside the Milky Way should include lessons about galaxies in general, and about our galaxy in particular. Following are a few suggestions:

- There are many beautiful images of galaxies on the web; see, for example, *http://hubblesite.org/gallery/album/galaxy*. An open-ended activity in which students classify galaxies according to their overall shape can be fun, and can also give students a good overview of the many types of galaxies in the universe.
- A popular activity that can help students envision themselves living inside the Milky Way is to have students write their "galactic address." That is, ask the students to write their return address on a letter to an imaginary friend in another galaxy. They will start with their normal address, then expand it to include their country, continent, planet, planetary system, and galaxy (see "Activity H1. Your Galactic Address" in Fraknoi 2011).
- One of the most interesting stories in the history of science was the discovery that our Sun is one star among about 200 billion in a huge cluster of stars called the Milky Way galaxy, and that there are billions of galaxies in the universe. Various chapters in the story can be researched by teams of students using the internet. For example, "Everyday Cosmology" at *http://cosmology.carnegiescience.edu* includes the following facts:
    - In 1609 Galileo is the first to see that the Milky Way consists of stars.
    - In 1781 William Herschel realizes we probably live within a disc of stars.
    - In 1912 Henrietta Leavitt discovers how to find the distance to millions of stars.
    - In 1920 Harlow Shapley finds our place in the Milky Way.
    - In 1923 Edwin Hubble measures the distance to the Andromeda galaxy.
    - In 1929 Hubble discovers that galaxies are moving apart from each other.
- You might explain to the students that before Edwin Hubble measured the distance to the Andromeda galaxy, many astronomers believed that there was just one galaxy in space—our own Milky Way—and that the cloudlike clusters of stars that could be seen through telescopes were part of our own galaxy.
- High school students should learn as much as possible about the overall shape of the Milky Way and its constituents; the following websites have maps of the Milky Way:
    - *www.atlasoftheuniverse.com/milkyway.html*
    - *www.universetoday.com/22766/map-of-the-milky-way*

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